The second view receives a certain amount of support from the fact that such fusions are known in other yeasts, *e.g.*, *Saccharomyces Ludwigii* (Hans), but in these cases growth is active, and there does not seem to be any nuclear fusion.

Having regard to the behaviour of the nuclear contents and the subsequent formation of spores, the third view seems most likely. Looking upon the process then as a sexual act of the simplest kind, and in view of the fact that, while all its other characters accord with those of Saccharomyces, it differs from the latter in the manner of its spore-formation, it is proposed to place it in a new genus, *Zygo-saccharomyces*, on the analogy of the genus Schizo-saccharomyces, suggested by Beyerinck for the fission-yeasts.

"The Measurement of Magnetic Hysteresis." By G. F. C. Searle, M.A., and T. G. Bedford, M.A. Communicated by Professor J. J. Thomson, F.R.S. Received May 2,—Read June 6, 1901.

(Abstract.)

§ 1. In 1895 one of the authors described* a method of measuring hysteresis by observation of the throw of a ballistic electro-dynamometer. The method in its most elementary form is very simple. An iron ring of section A and mean circumference l is uniformly wound with Nl turns of primary winding, and the primary current C passes also round the fixed coils of an electro-dynamometer. A secondary coil of n turns wound on the ring is connected in series with the suspended coil of the dynamometer and an earth inductor, the total resistance of the circuit being S.

The effects of self-induction in the secondary circuit being neglected, the secondary current c is

$$c = \frac{\mathrm{A}n}{\mathrm{S}} \frac{d\mathrm{B}}{dt}.$$

If the couple acting on the suspended coil due to the currents C, c be $q\mathrm{C}c$, then at any instant

$$\text{Couple} = q\mathrm{C}c = q\,\frac{\mathrm{A}n}{4\pi\mathrm{NS}}\,\mathrm{H}\,\frac{d\mathrm{B}}{dt},$$

since $\mathrm{H} = 4\pi\mathrm{NC}$, when the magnetic force due to c is neglected.

If the instrument be used ballistically, the angular momentum acquired by the coil while C changes from C_0 to $-\mathrm{C}_0$, is

$$\mathrm{K}\omega = q\int \mathrm{C}c\,dt = q\,\frac{\mathrm{A}n}{4\pi\mathrm{NS}}\int \mathrm{H}\,d\mathrm{B}.$$

* G. F. C. Searle, "A Method of Measuring the Loss of Energy in Hysteresis," 'Camb. Phil. Soc., Proc.,' vol. 9, Part I, 11th November, 1895.

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Now let the earth inductor be inverted, and so produce a change of induction P, and let the primary current at the time be C′, then

$$\mathrm{K}\omega' = q\mathrm{C}'\int c\,dt = q\mathrm{C}'\mathrm{P}/\mathrm{S}.$$

If θ_1, θ_2 be the two throws which occur when C changes from C_0 to $-\mathrm{C}_0$ and from $-\mathrm{C}_0$ to C_0, and if ϕ be the throw due to the earth inductor, then $\theta/\phi = \omega/\omega'$ and thus for a complete cycle,

$$\mathrm{W} = \frac{1}{4\pi}\int \mathrm{H}\,d\mathrm{B} = \frac{\mathrm{C}'\mathrm{PN}}{\mathrm{A}n\phi}(\theta_1+\theta_2).$$

Thus the sum of the two throws θ_1 and θ_2 is a measure of the energy dissipated in hysteresis in a complete cycle. When the factor $\mathrm{C}'\ \mathrm{PN}/\mathrm{A}n\phi$ has been determined, measurements of hysteresis can be made as rapidly as measurements of induction with a ballistic galvanometer.

§ 2. In developing a more complete theory the authors employ the equations

$$\mathrm{E} = \mathrm{RC} + \frac{d}{dt}(\mathrm{N}l\mathrm{AB} + \mathrm{L}'\mathrm{C} + \mathrm{M}c),$$

$$0 = \mathrm{S}c + \frac{d}{dt}(n\mathrm{AB} + \mathrm{MC} + \mathrm{L}c).$$

With the aid of the principle of the conservation of energy, these equations lead to the result

$$\begin{aligned}\mathrm{W} &= \frac{\mathrm{C}'\mathrm{NP}}{\mathrm{A}n\phi}(\theta_1+\theta_2) - \frac{16\pi^2\mathrm{N}^2\mathrm{QA}}{\sigma}\int\left(\frac{d\mathrm{B}}{d\mathrm{H}}\right)^2\frac{d\mathrm{C}}{dt}\,d\mathrm{C} \\ &\qquad - \frac{\mathrm{N}}{\mathrm{SA}n}\int\left(\frac{4\pi n^2\mathrm{A}}{l}\frac{d\mathrm{B}}{d\mathrm{H}}+\mathrm{L}\right)\left(4\pi n\mathrm{AN}\frac{d\mathrm{B}}{d\mathrm{H}}+\mathrm{M}\right)\frac{d\mathrm{C}}{dt}\,d\mathrm{C} \\ &= \mathrm{U} - \mathrm{X} - \mathrm{Y}.\end{aligned}$$

Here σ is the specific resistance of the specimen, and Q a numerical constant depending upon the geometrical form of the section, having the value $1/8\pi$ or 0·03979 for a circle and 0·03512 for a square.

The term U is determined by the dynamometer throws. The term X is the energy dissipated in eddy currents in the specimen during the two semi-cycles, and Y is roughly the energy spent in heating the secondary circuit.

It is shown that Y, when appreciable, can be determined by making two observations for U with two different values for S. In the authors' experiments Y was nearly always negligible. When a suitable key is employed to reverse the current, X + Y can be determined by making two observations for U with two different resistances of the primary circuit, the E.M.F. being at the same time so altered as to produce the same maximum current C_0 in each case.

This method of determining X + Y has lately been used successfully at the Cavendish Laboratory by Mr. R. L. Wills in the case of specimens of large section. In the authors' experiments X was generally negligible.

As the corrections X and Y depend upon dC/dt it is necessary that the primary current should change only gradually. By inserting a choking coil of great self-induction in the primary circuit, and by using a special key to cause the reversal of the current, this end is satisfactorily attained.

The authors have made many comparisons between the values of W found by their method and those calculated from the areas of cyclic B–H curves obtained by a ballistic galvanometer, and have found satisfactory agreement.

§ 3. By using a ballistic galvanometer in addition to the dynamometer, the two authors were able to make simultaneous observations of the range of the magnetic induction $\pm B_0$ and of the energy dissipated in each cycle. The range of the magnetic force $\pm H_0$ was also observed.

It was found that the cyclic B–H curve is not always divided into two parts of equal area by the line $H = 0$. The effect is well marked in the case of an iron wire freshly annealed, and sometimes does not disappear in spite of many reversals.

When the magnetic force is reversed many times both B_0 and W decrease. The effect is most apparent in soft iron freshly annealed, and subjected to a small magnetic force. Thus when the limits of H were $\pm 2{\cdot}5$, in the first cycle after the annealing, $B_0 = 2220$ and $W = 598$. In the forty-first cycle $B_0 = 1840$, $W = 433$.

§ 4. When an iron wire is stretched by a variable load, and is put through cycles with the limits $\pm H_0$, the first application of the tension results in an increase in both B_0 and W. As the tension increases, B_0 and W reach maxima and then decrease. The effect is more marked when H_0 is small than when it is large. Thus with a wire of section 0·00708 cm.^{2} a load of 16 kilos. raised B_0 from 1233 to 5870 and W from 494 to 3820, with $H_0 = 4{\cdot}524$.

A series of experiments was made upon the effects of torsion. When H_0 is kept constant, as the torsion increases there is a large decrease in both B_0 and W. Thus in the case of a soft iron wire when $H = 3{\cdot}0$, by torsion within the elastic limit B_0 was brought down from 2280 to 1070 and W from 907 to 276. Further, both B_0 and W exhibit hysteresis with respect to the torsion.

Experiments were also made in which the torsion was gradually increased till the wire broke. In other experiments the authors studied the influence of permanent torsional set upon the effects of cycles of torsion. They also examined the development of a cyclic state, for cycles of torsion, after initial permanent torsional set.

In all these experiments, the curves showing W in terms of the stress, bear a close resemblance to those showing B_0 in terms of the stress. To examine this point, curves were plotted showing how W varies with B_0, when H_0 is kept constant and B_0 is varied by varying the stress.

For both tension and torsion each curve for a given value of H_0 takes the form of a straight line having a hook at one end. The straight portions of the separate curves for different values of H_0 all pass, on prolongation, through a single point, generally on the line $B_0 = 0$. Thus the straight parts are represented by $W = mB_0 - b$. Plotting m against H_0 it is found that $m = aH_0^{\frac{1}{2}}$, and thus the formula becomes $W = aH_0^{\frac{1}{2}}B_0 - b$, where a and b are constants. It is found that this formula represents W closely when both H_0 and B_0 vary over a considerable range in the neighbourhood of the maximum permeability, the iron being now free from stress.

§ 5. An electric current flowing along an iron wire magnetises it circularly, and may be expected to diminish both B_0 and W for the given limits $\pm H_0$. Experiment showed that the expected effect occurs, a current of 1·123 ampere through an iron wire about 1 mm. in diameter diminishing W by 22·7 per cent.

§ 6. The numerical values of the quantity Q, which occurs, in § 2, in the expression for the heat produced by the eddy currents in the specimen, are calculated in Appendix I for rods of both circular and rectangular sections.

§ 7. In their experiments the authors have used straight iron wires about 50 cm. in length. They discuss the effect of the de-magnetising force due to the induced magnetism of the specimen, and show how to apply corrections to the value of W calculated from the formula $1/4\pi \, . \int H' dB'$, where H' is the magnetic force due to the current, and B' is the magnetic induction at the centre of the wire; they also give numerical examples of these corrections. Appendix II contains an account of experiments made to find the de-magnetising force h under two sets of conditions. In the first case, h was determined when $H = H_0$, after many magnetic cycles with the limits $\pm H_0$. Using a freshly annealed wire, and increasing H_0 from 0 to 124 C.G.S., h was found to rise to a maximum, which occurred nearly when μ had its maximum value; the maximum was followed by a minimum of h, and the value of h for the largest values of H_0 was *less* than that which would obtain if the induction through the centre of the wire flowed in and out only by the *ends* of the wire. This small value of h implies the existence, between the centre and either end of the wire, of a "pole" of sign opposite to that of the pole at the end, a circumstance only to be accounted for by the effects of hysteresis. In the second case h was found for several points on the cyclic B–H curve, and curves are given showing h in relation to both H and B. In both curves h

exhibits very marked hysteresis with respect to H and B. Over a part of the cyclic h–B curve, the direction of h is *opposite* to that corresponding to the direction of the induction at the centre of the wire. The results obtained show that the method of "shearing" usually adopted to correct B–H curves for the effects of the de-magnetising force must be used with great caution.

The paper is illustrated by diagrams of apparatus and by curves showing the experimental results.

"Thermal Adjustment and Respiratory Exchange in Monotremes and Marsupials.—A Study in the Development of Homothermism." By C. J. Martin, M.B., D.Sc., Acting Professor of Physiology in the University of Melbourne. Communicated by E. H. Starling, F.R.S. Received May 14,—Read June 6, 1901.

(Abstract.)

A number of observations on the relations between the body temperature, and the temperature of the surrounding medium, and on the respiratory exchanges in monotremes and marsupials are recorded. The results are compared with those obtained in control experiments with cold-blooded animals (lizards) and higher mammals.

The main conclusions arrived at are—

1. Echidna is the lowest in the scale of warm-blooded animals. Its attempts at homothermism fail to the extent of 10° when the environment varies from 5° to 35° C. During the cold weather, it hibernates for four months, and at this time its temperature is only a few tenths of a degree above that of its surroundings. The production of heat in Echidna is proportional to the difference in temperature between animal and environment. At high temperatures, it does not increase the number and depth of its respirations. It possesses no sweat glands, and exhibits no evidence of varying loss of heat by vaso-motor adjustment of superficial vessels in response to external temperature.

2. Ornithorhyncus is a distinct advance upon Echidna. Its body temperature though low is fairly constant. It possesses abundant sweat glands upon the snout and frill, but none elsewhere. The production of carbonic acid with varying temperatures of environment indicates that the animal can modify heat-loss as well as heat-production. Its respiratory efforts do not increase with high temperatures.

3. Marsupials show evidence of utilising variations in loss to an extent greater than Ornithorhyncus, but less than higher mammals. Their respirations slightly increase in number at high temperatures.